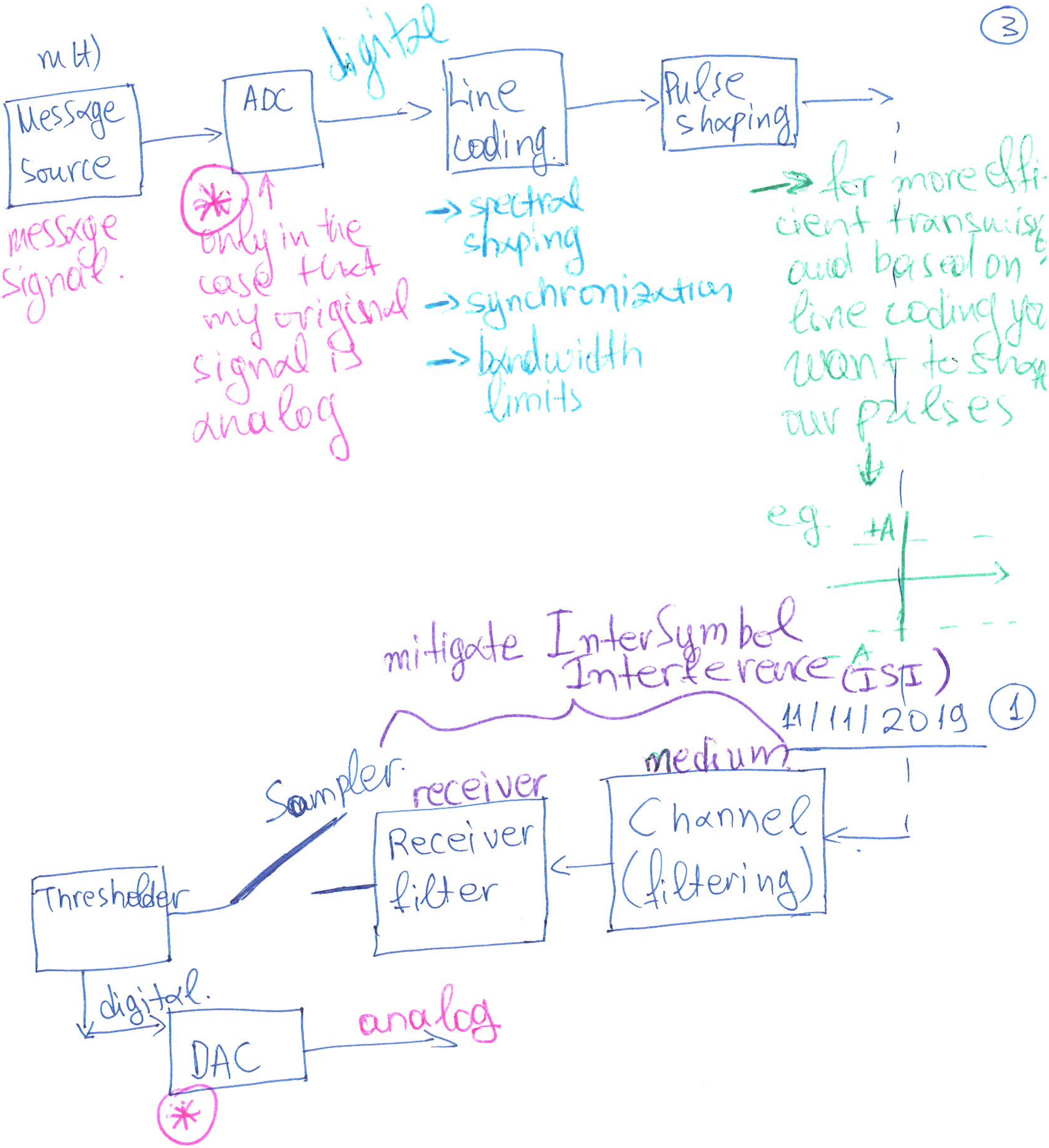
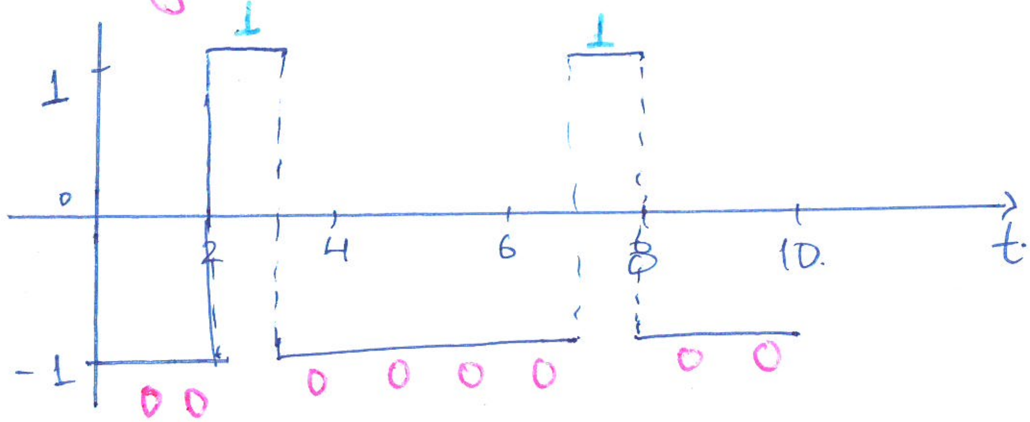

3
m(t)
Message Source
message signal.
ADC
digital
only in the case that my original signal is analog
Line coding.
spectral shaping
synchronization
bandwidth limits
Pulse shaping
for more efficient transmission and based on line coding you want to shape our pulses
e.g.
+A
-A
mitigate InterSymbol Interference (ISI)
11/11/2019
1
medium
Channel (filtering)
receiver
Receiver filter
Sampler.
Thresholder
digital.
DAC
analog

1) Non-return-to-zero (NRZ) Line Coding

1 : positive level of +A

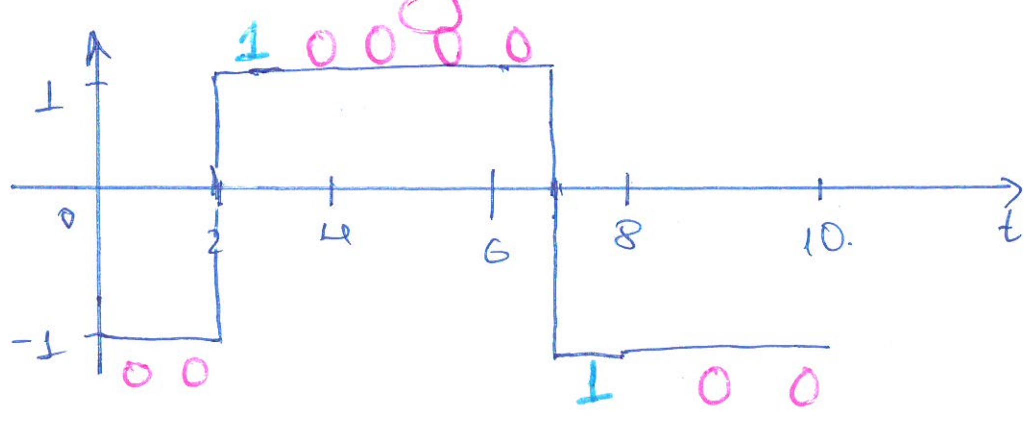
0 : negative level of −A



2) NRZ mark :

1 : change the level

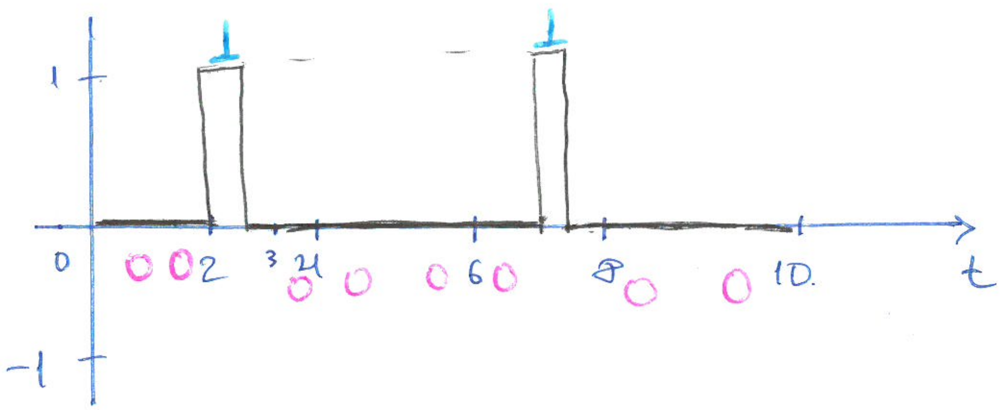
0 : no change



3) Unipolar return-to-zero (RZ):

1 : $\frac{1}{2}$ width of the pulse

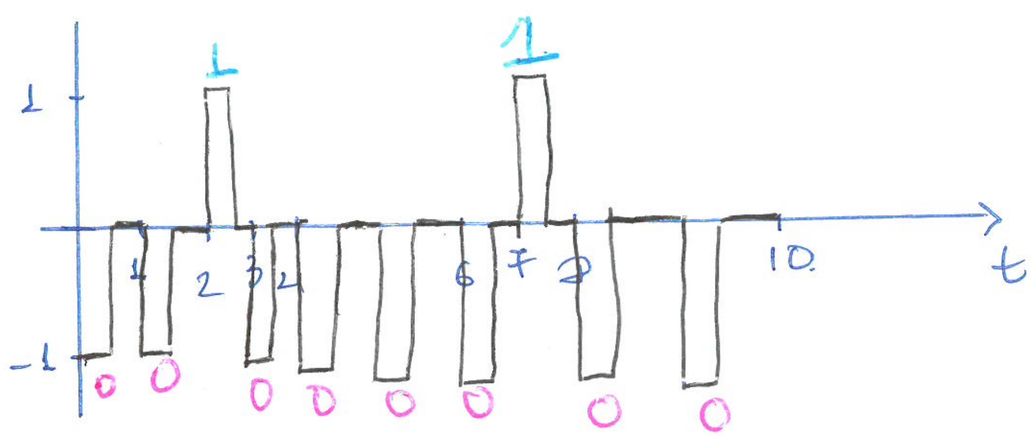
0 : no pulse



4) Polar RZ

1 : positive RZ pulse

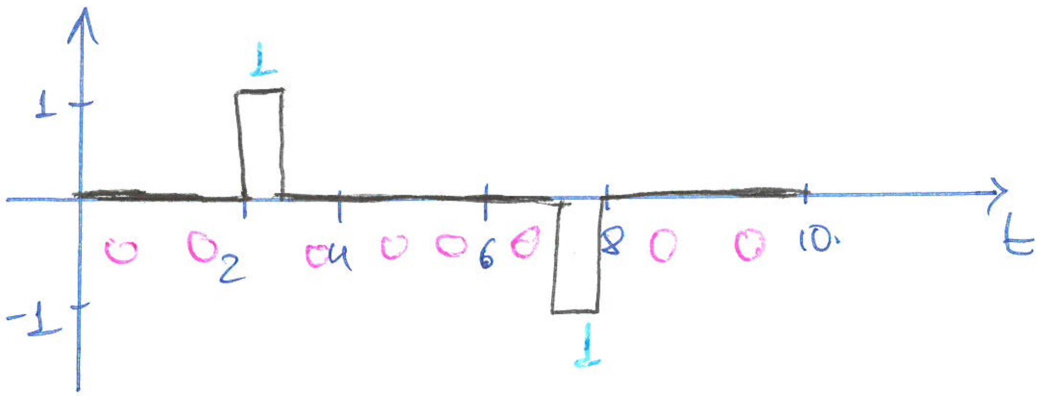
0 : negative RZ pulse.



5) Bipolar RZ

1 : RZ pulse alternates the sign

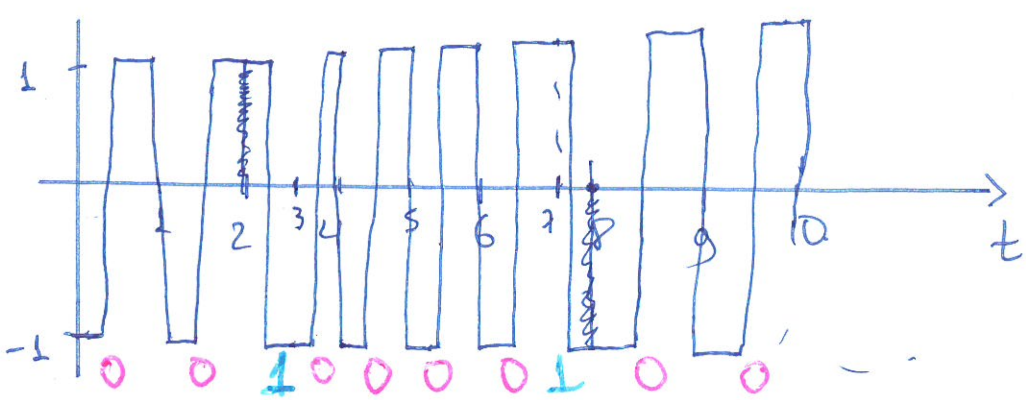
0 : level 0



6) Split Phase (Manchester)

1 : A switches -A at the half of the symbol period

0 : -A -> +A



Criteria of selecting a line coding technique.

1) Self-synchronization
2) Power spectrum suitable for the particular channel that I'm using
3) Transmission Bandwidth
4) Transparency
5) Error Detection capability
6) Good bit error probability performance.

Power Spectra for Line-Coded Data.

Pulse-train signal

$$x(t) = \sum_{k=-\infty}^{+\infty} a_k \, p(t - kT - \Delta)$$

pulse period

random variables with average

$$R_m = \langle a_k \cdot a_{k+m} \rangle$$

random variable uniformly distributed within $\left(-\frac{T}{2}, \frac{T}{2}\right)$.

Autocorrelation Function
$$R_x(\tau) = \sum_{m=-\infty}^{+\infty} R_m \, r(\tau - mT)$$

$$r(\tau) = \frac{1}{T}\int_{-\infty}^{+\infty} p(t+\tau)p(t)\,dt$$

Power Spectral Density
$$S_x(f) = \mathcal{F}\{R_x(\tau)\} =$$
$$= \mathcal{F}\left\{\sum_{m=-\infty}^{+\infty} R_m \, r(\tau - mT)\right\} =$$
$$= \sum_{m=-\infty}^{+\infty} R_m \, \mathcal{F}\{r(\tau - mT)\}$$
$$= \sum_{m=-\infty}^{+\infty} R_m \, S_r(f) \, e^{-j2\pi mTf}$$
$$= \boxed{S_r(f)\cdot} \sum_{m=-\infty}^{+\infty} R_m \cdot e^{-j2\pi mTf}$$

Pulse-train function $p(t) \Leftrightarrow P(f) = \mathcal{F}\{p(t)\}$

$$\boxed{S_r(f) = \frac{|P(f)|^2}{T}}$$ Power spectral density

Example: NRZ

Pulse shape function for NRZ $\quad p(t) = \Pi\left(\frac{t}{T}\right) \longleftrightarrow$

$$P(f) = T \cdot \operatorname{sinc}(T \cdot f)$$

$$S_r(f) = \frac{1}{T} \left| T \cdot \operatorname{sinc}(Tf) \right|^2 = T \cdot \operatorname{sinc}^2(Tf)$$

$$R_m = \begin{cases} \frac{1}{2}A^2 + \frac{1}{2}(-A)^2 = A^2, & m = 0 \\ \frac{1}{4}A \cdot (-A) + \frac{1}{4}(-A) \cdot A + \frac{1}{4}A^2 + \frac{1}{4}(-A^2) = 0, & m \neq 0 \end{cases}$$

$$S_{NRZ}(f) = A^2 \cdot T \cdot \operatorname{sinc}^2(Tf)$$

Example: Manchester

Pulse shape function $\quad p(t) = \Pi\left(\frac{t + \frac{T}{4}}{\frac{T}{2}}\right) - \Pi\left(\frac{t - \frac{T}{4}}{\frac{T}{2}}\right) \Leftarrow$

8

$$\Leftrightarrow P(f) = \frac{T}{2}\,\mathrm{sinc}\left(\frac{T}{2}f\right)\cdot e^{j2\pi\frac{T}{4}f} - \frac{T}{2}\,\mathrm{sinc}\left(\frac{T}{2}f\right)\cdot e^{-j2\pi\frac{T}{4}f}$$

$$= \frac{T}{2}\,\mathrm{sinc}\left(\frac{T}{2}f\right)\cdot\left(e^{j2\pi\frac{T}{4}\frac{f}{2}} - e^{-j2\pi\frac{T}{4}\frac{f}{2}}\right)$$

$$= jT\cdot\mathrm{sinc}\left(\frac{T}{2}f\right)\sin\left(\pi\frac{T}{2}f\right)$$

$$\Rightarrow S_r(f) = \frac{|P(f)|^2}{T} = \frac{1}{T}\left|jT\,\mathrm{sinc}\left(\frac{T}{2}f\right)\sin\left(\pi\frac{T}{2}f\right)\right|^2$$

$$= T\cdot\mathrm{sinc}^2\left(\frac{T}{2}f\right)\cdot\sin^2\left(\pi\frac{T}{2}f\right)$$

$$S_{Manchester}(f) = A^2T\cdot\mathrm{sinc}^2\left(\frac{T}{2}f\right)\cdot\sin^2\left(\frac{\pi T}{2}f\right)$$